MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2019/2020

ECT2036 – CIRCUITS AND SIGNALS

(TE, RE)

21 OCTOBER 2019

9:00 am – 11:00 am
(2 Hours)

INSTRUCTIONS TO STUDENT

1. This Question paper consists of 8 pages including cover page with 4 Questions only.

2. Attempt **ALL** the questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please write all your answers in the Answer Booklet provided.

4. Appendix is provided after the question pages.

Question 1

a) Given the network in Figure Q1(a) below with each branch numbered;

i. Draw the *oriented network graph* and label each branch and node accordingly. [3 marks]

ii. Derive the *mesh incidence matrix* for the network graph drawn in (i). [3 marks]

iii. Solve for the mesh currents i_{m1}, i_{m2} and i_{m3} of the network graph given that

$$Z_M^{-1} = \begin{bmatrix} 0.314 & 0.137 & 0.118 \\ 0.137 & 0.373 & 0.176 \\ 0.118 & 0.176 & 0.294 \end{bmatrix}$$ [7 marks]

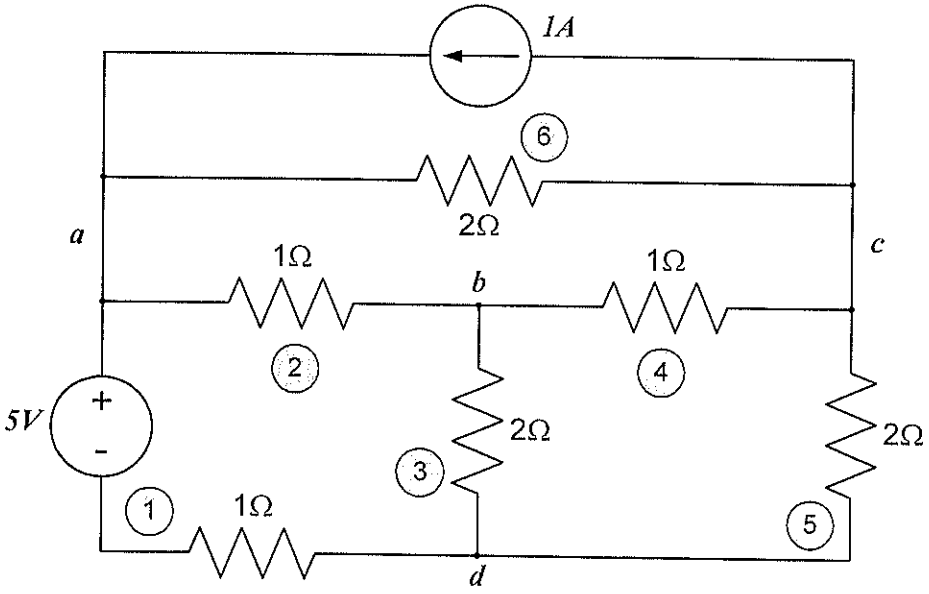

Figure Q1(a)

b) Determine whether the signal $x(t)$ is a *power* or *energy* signal.

$$x(t) = A\,|\sin(\omega t + \theta)|$$ [3 marks]

c) Perform the discrete-time convolution at n = 3 for

$$f_1[n] = \left[\left(\frac{2}{3}\right)^n - \left(\frac{3}{5}\right)^n\right]u[n] \quad \textit{and} \quad f_2[n] = 2n\,u[n-1]$$

[9 marks]

Continued...

Question 2

a) Determine the inverse Laplace transform of the following functions:

i. $F(s)=\dfrac{4s+5}{(s+1)(s+2)^2}$ [5 marks]

ii. $F(s)=e^{-2s}\dfrac{s+2}{s^2+6s+18}$ [5 marks]

b) The switch of the circuit in Figure Q2(b) has been at position X for a long time. At time t = 0, it is flipped to Y.

i. Draw its equivalent s-domain transformed circuit for $t > 0$. [5 marks]

ii. Determine $v_L(t)$ for $t > 0$. [10 marks]

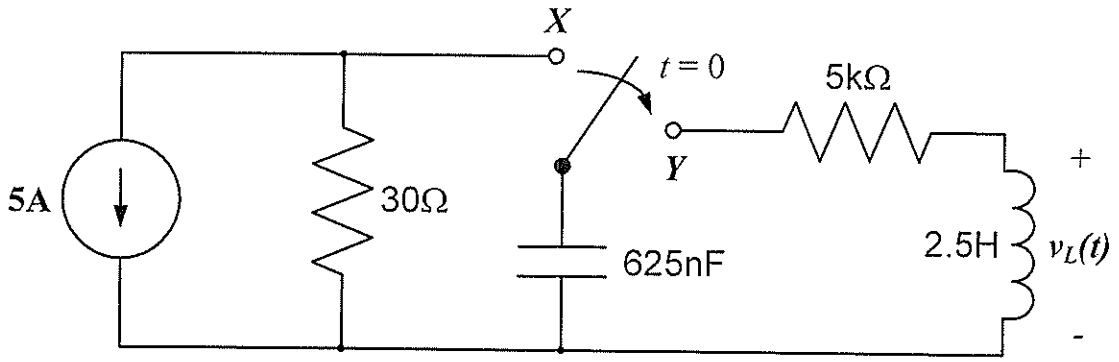

Figure Q2(b)

Continued...

Question 3

a) Find the *hybrid* parameter for the two-port network in Figure Q3(a).

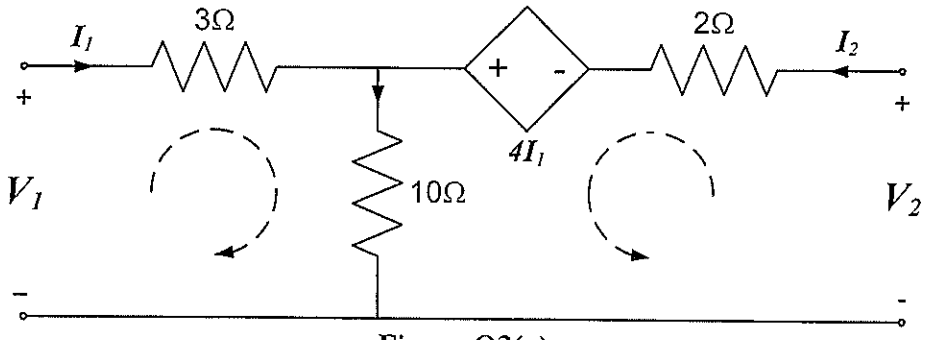

Figure Q3(a)

[12 marks]

b) Derive the *state variable model* of the circuit given in Figure Q3(b) if v_O is the output.

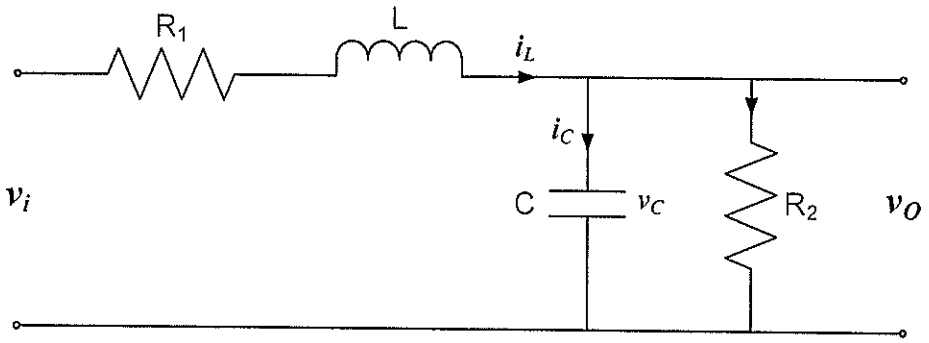

Figure Q3(b)

[13 marks]

Continued...

Question 4

a) Obtain the Foster I realisation of the following RC-admittance function:

$$Y(s)=\frac{s^2+5s+4}{4\left(s^2+7s+10\right)}$$

[13 marks]

b) Part of an amplifier circuit consists of a low-pass filter with a pass band and stop band attenuation of 4dB and 80db respectively. Using Butterworth approximation approach, determine the order of the filter if its passband to stopband frequency ratio is 0.4.

[12 marks]

Continued . . .

APPENDIXES

Chapter 1:

Nodal Analysis	Mesh Analysis
1. $Y_N = AYA^T$	1. $Z_M = BZB^T$
2. $e_{\text{Node}} = -Y_N{}^{-1}A(I+YE)$	2. $i_{\text{Mesh}} = Z_M{}^{-1}B(E+ZI)$
3. $e = A^T e_{\text{Node}}$	3. $i = B^T i_{\text{Mesh}}$
4. $i = Ye + (I+YE)$	4. $e = Zi - (E+ZI)$
Fundamental Cutset Analysis	**Fundamental Loop Analysis**
1. $Y_C = CYC^T$	1. $Z_L = DZD^T$
2. $e_{\text{Twig}} = -Y_C{}^{-1}C(I+YE)$	2. $i_{\text{Link}} = Z_L{}^{-1}D(E+ZI)$
3. $e = C^T e_{\text{Twig}}$	3. $i = D^T i_{\text{Link}}$
4. $i = Ye + (I+YE)$	4. $e = Zi - (E+ZI)$

Chapter 2:

Even signal: $f(t) = f(-t)$ or $f[n] = f[-n]$

Odd signal: $f(t) = -f(-t)$ or $f[n] = -f[-n]$

Energy content: $E = \lim_{T\to\infty} \int_{-T}^{T} f^2(t)dt$ or $E = \lim_{N\to\infty} \sum_{n=-N}^{N-1} f^2[n]$

Power content: $P = \lim_{T\to\infty} \frac{1}{2T} \int_{-T}^{T} f^2(t)dt$ or $P = \lim_{N\to\infty} \frac{1}{2N} \sum_{n=-N}^{N-1} f^2[n]$

Chapter 3: Laplace transform pairs

No.	*t*-domain function	*s*-domain transform
1.	$\delta(t)$	1
2.	$u(t)$	$1/s$
3.	$tu(t)$	$1/s^2$
4.	t^n	$\frac{n!}{s^{n+1}}$
5.	e^{-kt}	$\frac{1}{s+k}$
6.	$t^n e^{-kt}$	$\frac{n!}{(s+k)^{n+1}}$

Continued . . .

7.	$\sin\omega t$	$\frac{\omega}{s^2+\omega^2}$
8.	$\cos\omega t$	$\frac{s}{s^2+\omega^2}$
9.	$e^{-kt}\sin\omega t$	$\frac{\omega}{(s+k)^2+\omega^2}$
10.	$e^{-kt}\cos\omega t$	$\frac{s+k}{(s+k)^2+\omega^2}$
11.	$t\sin\omega t$	$\frac{2\omega s}{(s^2+\omega^2)^2}$

Chapter 4: Interrelation of parameters

	z	y	h	g	$ABCD$	$abcd$
z	$\begin{matrix} z_{11} & z_{12} \\ z_{21} & z_{22} \end{matrix}$	$\begin{matrix} \frac{y_{22}}{\Delta y} & \frac{-y_{12}}{\Delta y} \\ \frac{-y_{21}}{\Delta y} & \frac{y_{11}}{\Delta y} \end{matrix}$	$\begin{matrix} \frac{\Delta h}{h_{22}} & \frac{h_{12}}{h_{22}} \\ \frac{-h_{21}}{h_{22}} & \frac{1}{h_{22}} \end{matrix}$	$\begin{matrix} \frac{1}{g_{11}} & \frac{-g_{12}}{g_{11}} \\ \frac{g_{21}}{g_{11}} & \frac{\Delta g}{g_{11}} \end{matrix}$	$\begin{matrix} \frac{A}{C} & \frac{\Delta a}{C} \\ \frac{1}{C} & \frac{D}{C} \end{matrix}$	$\begin{matrix} \frac{d}{c} & \frac{1}{c} \\ \frac{\Delta b}{c} & \frac{a}{c} \end{matrix}$
y	$\begin{matrix} \frac{z_{22}}{\Delta z} & \frac{-z_{12}}{\Delta z} \\ \frac{-z_{21}}{\Delta z} & \frac{z_{11}}{\Delta z} \end{matrix}$	$\begin{matrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{matrix}$	$\begin{matrix} \frac{1}{h_{11}} & \frac{-h_{12}}{h_{11}} \\ \frac{h_{21}}{h_{11}} & \frac{\Delta h}{h_{11}} \end{matrix}$	$\begin{matrix} \frac{\Delta g}{g_{22}} & \frac{g_{12}}{g_{22}} \\ \frac{-g_{21}}{g_{22}} & \frac{1}{g_{22}} \end{matrix}$	$\begin{matrix} \frac{D}{B} & \frac{-\Delta a}{B} \\ \frac{-1}{B} & \frac{A}{B} \end{matrix}$	$\begin{matrix} \frac{a}{b} & \frac{-1}{b} \\ \frac{-\Delta b}{b} & \frac{d}{b} \end{matrix}$
h	$\begin{matrix} \frac{\Delta z}{z_{22}} & \frac{z_{12}}{z_{22}} \\ \frac{-z_{21}}{z_{22}} & \frac{1}{z_{22}} \end{matrix}$	$\begin{matrix} \frac{1}{y_{11}} & \frac{-y_{12}}{y_{11}} \\ \frac{y_{21}}{y_{11}} & \frac{\Delta y}{y_{11}} \end{matrix}$	$\begin{matrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{matrix}$	$\begin{matrix} \frac{g_{22}}{\Delta g} & \frac{-g_{12}}{\Delta g} \\ \frac{-g_{21}}{\Delta g} & \frac{g_{11}}{\Delta g} \end{matrix}$	$\begin{matrix} \frac{B}{D} & \frac{\Delta a}{D} \\ \frac{-1}{D} & \frac{C}{D} \end{matrix}$	$\begin{matrix} \frac{b}{a} & \frac{1}{a} \\ \frac{-\Delta b}{a} & \frac{c}{a} \end{matrix}$
g	$\begin{matrix} \frac{1}{z_{11}} & \frac{-z_{12}}{z_{11}} \\ \frac{z_{21}}{z_{11}} & \frac{\Delta z}{z_{11}} \end{matrix}$	$\begin{matrix} \frac{\Delta y}{y_{22}} & \frac{y_{12}}{y_{22}} \\ \frac{-y_{21}}{y_{22}} & \frac{1}{y_{22}} \end{matrix}$	$\begin{matrix} \frac{h_{22}}{\Delta h} & \frac{-h_{12}}{\Delta h} \\ \frac{-h_{21}}{\Delta h} & \frac{h_{11}}{\Delta h} \end{matrix}$	$\begin{matrix} g_{11} & g_{12} \\ g_{21} & g_{22} \end{matrix}$	$\begin{matrix} \frac{C}{A} & \frac{-\Delta a}{A} \\ \frac{1}{A} & \frac{B}{A} \end{matrix}$	$\begin{matrix} \frac{c}{d} & \frac{-1}{d} \\ \frac{\Delta b}{d} & \frac{b}{d} \end{matrix}$
A B C D	$\begin{matrix} \frac{z_{11}}{z_{21}} & \frac{\Delta z}{z_{21}} \\ \frac{1}{z_{21}} & \frac{z_{22}}{z_{21}} \end{matrix}$	$\begin{matrix} \frac{-y_{22}}{y_{21}} & \frac{-1}{y_{21}} \\ \frac{-\Delta y}{y_{21}} & \frac{-y_{11}}{y_{21}} \end{matrix}$	$\begin{matrix} \frac{-\Delta h}{h_{21}} & \frac{-h_{11}}{h_{21}} \\ \frac{-h_{22}}{h_{21}} & \frac{-1}{h_{21}} \end{matrix}$	$\begin{matrix} \frac{1}{g_{21}} & \frac{g_{22}}{g_{21}} \\ \frac{g_{11}}{g_{21}} & \frac{\Delta g}{g_{21}} \end{matrix}$	$\begin{matrix} A & B \\ C & D \end{matrix}$	$\begin{matrix} \frac{d}{\Delta b} & \frac{b}{\Delta b} \\ \frac{c}{\Delta b} & \frac{a}{\Delta b} \end{matrix}$
a b c d	$\begin{matrix} \frac{z_{22}}{z_{12}} & \frac{\Delta z}{z_{12}} \\ \frac{1}{z_{12}} & \frac{z_{11}}{z_{12}} \end{matrix}$	$\begin{matrix} \frac{-y_{11}}{y_{12}} & \frac{-1}{y_{12}} \\ \frac{-\Delta y}{y_{12}} & \frac{-y_{22}}{y_{12}} \end{matrix}$	$\begin{matrix} \frac{1}{h_{12}} & \frac{h_{11}}{h_{12}} \\ \frac{h_{22}}{h_{12}} & \frac{\Delta h}{h_{12}} \end{matrix}$	$\begin{matrix} \frac{-\Delta g}{g_{12}} & \frac{-g_{22}}{g_{12}} \\ \frac{-g_{11}}{g_{12}} & \frac{-1}{g_{12}} \end{matrix}$	$\begin{matrix} \frac{D}{\Delta a} & \frac{B}{\Delta a} \\ \frac{C}{\Delta a} & \frac{A}{\Delta a} \end{matrix}$	$\begin{matrix} a & b \\ c & d \end{matrix}$

Continued . . .

$\Delta z = z_{11}z_{22} - z_{12}z_{21}$; $\Delta y = y_{11}y_{22} - y_{12}y_{21}$

$\Delta h = h_{11}h_{22} - h_{12}h_{21}$; $\Delta g = g_{11}g_{22} - g_{12}g_{21}$

$\Delta a = AD - BC$; $\Delta b = ad - bc$

Chapter 7: Polynomial functions of $C_n(\omega)$ of a low-pass Chebyshev filter

Order n	Polynomial $C_n(\omega)$
0	1
1	ω
2	$2\omega^2 - 1$
3	$4\omega^3 - 3\omega$
4	$8\omega^4 - 8\omega^2 + 1$
5	$16\omega^5 - 20\omega^3 + 5\omega$
6	$32\omega^6 - 48\omega^4 + 18\omega^2 - 1$
7	$64\omega^7 - 112\omega^5 + 56\omega^3 - 7\omega$

End of paper.